APPLICATION FOR
UNITED STATES LETTER PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, **Art Whitworth**, a citizen of the United States, and resident of the United States of America, having a postal address of 215 S. 4th Street Winterset, IA 50273-1916 have invented new and useful "**MODIFIED SAVONIUS ROTOR**", of which the following forms the specification.

"MODIFIED SAVONIUS ROTOR"

CROSS REFERENCE TO RELATED APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO MICROFICHE APPENDIX

Not applicable.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to an alternate source of energy. More particularly the present invention relates to a modification to a Savonius wind turbine rotor for converting kinetic energy in the wind to shaft power.

Background Art

Shaft power has been derived from the wind for centuries. Dutch windmills were first used for grist, and later converted to raising water to sea level for land reclamation.

Wind power was commonly harnessed across the prairie and plains states in the U.S. for pumping water from wells. In the early part of the 20th century, wind was utilized for converting kinetic energy to electrical energy.

The last quarter of the 20th century saw a marked increase in interest in converting wind energy to shaft power. Many units from that era were horizontal shaft wind turbines using airfoils of various types. Drawbacks of such an arrangement are the need to have the power unit (generator, air compressor, etc.) on top of the tower with the airfoils, or the need for gearing to transfer the power toward the ground.

Efforts have been made toward improving vertical-shaft wind turbines as well. The Darius rotor utilizes airfoils in a fashion quite different than the horizontal shaft units. However, the Darius rotor is not self-starting, so a starting scheme is required.

The Savonius rotor is a self-starting, low-speed, vertical axis wind turbine (the axis need not be vertical, however, that is the usual configuration). However, in its traditional form (see **Fig. 1**), the Savonius rotor is known to exhibit low efficiencies. It is known as a drag-type wind turbine, as opposed to the lift-type wind turbines having horizontal axes and the Darius rotor. Rotation of the Savonius rotor is effected through momentum transfer from the air. The momentum of the air changes as its path is curved by the vanes of the Savonius rotor. Momentum exchange occurs on entrance to the vanes and on exit from the vanes. The change in momentum with time results in forces that tend to turn the Savonius rotor on its axis of rotation.

A modification to the Savonius rotor of **Fig. 1** was disclosed in U.S. Patent 5,494,407. The blades of this invention have been altered from half-circles in cross-section as seen in **Fig. 1** to the shape shown in **Fig. 2,** having a linear portion nearer the axis of rotation and a curved portion, which is substantially an arc of a circle tangent to the linear portion and tangent to the circle defining the rotor diameter.

Another modification to the Savonius rotor of **Fig. 1** is revealed in U.S. Patent 6,283,711 wherein an additional, outer vane that is pivotally attached to the original, semicylindrical blade at the latter's leading edge.

A novel modification to the traditional Savonius rotor is shown in **Fig. 3** wherein the vanes are reduced in size away from a vertical center such that they reach apexes at

the top and bottom of the unit. Such a wind turbine can be made of light fabric material.

In all the prior art, the air flows into the cavity created by a vane, then is directed along a path that is substantially parallel to the vane until it exits the first vane and enters the second vane. The streamlines are, again, substantially parallel to this second vane. The air is finally exhausted downstream of the wind turbine to the freestream. None of the prior art discloses an exhaust port to permit air to exit the first vane without traveling through the second vane.

In addition, the known prior art does not reveal the use of Savonius rotor vanes as a surface on which to apply a solar panel.

There is, therefore, a need for an improved exit path for air to exhaust from a vane in a Savonius rotor. There is an additional need for the use of Savonius rotor vanes as a surface on which to apply solar panels.

BRIEF SUMMARY OF THE INVENTION

An object of the present invention is to provide a flow path for exiting air from a Savonius rotor without passing through a channel produced by a first and second vanes.

To effect the modification of a Savonius rotor, the two vanes are formed in a single "S" shapes vane and channels are provided, preferably along a lower edge of the vane and extending at least halfway up the vane. Through the channel is a flow path for the air to pass through the vane from the convex portion of the vane to the freestream. In shape, the exhaust channel transitions smoothly from the vane, in a shape roughly similar to a cylinder diverging from the vane.

The airflow will, in the preferred embodiment and in a coordinate system attached to the rotating modified Savonius rotor, pass along the curved vane of the Savonius rotor, thereby undergoing a change in its momentum and, therefore, imparting a force on the modified Savonius rotor causing the rotor to spin. As the air continues toward the axis of rotation of the modified Savonius rotor but before it reaches the axis of rotation, it exits through the exhaust channel which leads to the freestream.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in

conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a plan view of a Savonius rotor of the prior art with semicylindrical vanes;

Fig. 2 is a plan view of a first modified Savonius rotor of the prior art;

Fig. 3 is a plan view of a second modified Savonius rotor of the prior art;

Fig. 4 is a perspective view of a modified Savonius rotor assembly of the present invention with a load and tower;

Fig. 5 is a first top plan view of a modified Savonius rotor;

Fig. 6 is a detail of a lower flange of the modified Savonius rotor;

Fig. 7 is a first top plan view of the modified Savonius rotor;

Fig. 8 is a first detail of an exhaust channel of the modified Savonius rotor;

Fig. 9 is a first plan view of the modified Savonius rotor assembly;

Fig. 10 is a second detail of an exhaust channel of the modified Savonius rotor;

Fig. 11 is a third detail of an exhaust channel of the modified Savonius rotor;

Fig. 12 is a side elevation view of the modified Savonius rotor;

Fig. 13 is a fourth detail of an exhaust channel of the modified Savonius rotor;

Fig. 14 is a fifth detail of an exhaust channel of the modified Savonius rotor;

Fig. 15 is a sixth detail of an exhaust channel of the modified Savonius rotor;

Fig. 16 is a perspective view of a slip ring assembly;

Fig. 17 is a detail of the slip ring assembly;

Fig. 18 is a perspective view of a second embodiment of the modified Savonius rotor assembly of the present invention with a load and tower;

Fig. 19 is a first top plan view of the second embodiment of a modified Savonius rotor;

Fig. 20 is a detail of a lower flange of the second embodiment of the modified Savonius rotor;

Fig. 21 is a first top plan view of the second embodiment of the modified

Savonius rotor;

Fig. 22 is a first detail of an exhaust channel of the second embodiment of the modified Savonius rotor;

Fig. 23 is a second detail of an exhaust channel of the second embodiment of the modified Savonius rotor;

Fig. 24 is a side elevation view of the second embodiment of the modified Savonius rotor;

Fig. 25 is a third detail of an exhaust channel of the second embodiment of the modified Savonius rotor;

Fig. 26 is a fourth detail of an exhaust channel of the second embodiment of the modified Savonius rotor;

Fig. 27 is a fifth detail of an exhaust channel of the second embodiment of the modified Savonius rotor;

Fig. 28 is a perspective view of an assembly of a third embodiment of the modified Savonius rotor;

DETAILED DESCRIPTION OF THE INVENTION

A set of three (3) modified Savonius rotors **405, 410, 415** are shown stacked vertically in **Fig. 4** in a rotor assembly **400** in a first embodiment of the invention. By angling the "S" shaped vanes differently for each set (in this case 120° apart), automatic startup is assured because at least one rotor will be turned such that the change in momentum of the wind will cause the assembly to turn. The set of modified Savonius rotors **405, 410, 415** in the assembly **400** are rigidly affixed to a shaft **420** which rotates as the modified Savonius rotors **405, 410, 415** rotate. A bearing (not shown) at a lower end of the shaft **420** provides reduced friction rotation. Via the shaft **420**, power is transmitted to a power converting device **425** such as an electrical generator, an air compressor, pump, etc. An advantage of the Savonius rotor over horizontal-shaft wind turbines is the ability to locate the power converting device **425** at or near ground level where it is accessible for installation, maintenance, repair, and inspection.

Usually, a tower **430** is used to elevate the modified Savonius rotor assembly **400**

into higher wind speeds to increase the power output of the power converting device **425**.

A support plate **450** is installed at the top of each of the modified Savonius rotors **405, 410, 415** and the bottom of the lowest modified Savonius rotor **405** to provide rigidity.

In this first embodiment of the invention, outer surfaces of the modified Savonius rotor assembly **400** are coated with photovoltaic cells as indicated by the crosshatching in **Figs. 1–17**.

In **Fig. 5** a top plan view of a single modified Savonius rotor is depicted. Top flanges **510** and bottom flanges **610** (see **Fig. 6**) provide stability for each end of the "S" shaped vane **710** (see **Fig. 7**) and channeling of the air along the vane's surface. The outsides of the exhaust channels **530** are clearly seen in **Fig. 5**, the exhaust channel being extending out from the convex faces of the vane **710**.

A plan view of an end of an "S" shaped vane from a horizontal midsection is seen in **Fig. 6**. A lower flange **610** is clearly seen, as well as a portion of the exhaust channel **530**. A metallic edge **620** is applied to the lower flange **610** to enhance rigidity and provide some protection from abrasion.

The top flanges **510** and upper support plate **450** have been removed in **Fig. 7** to more clearly see the "S" shaped vane **710** of the modified Savonius rotor. The exhaust channels **530** are seen from above. The air flow across one end of the vane **710** for a given position of the vane **710** is indicated.

Fig. 8 is a cross section of a lower portion of a modified Savonius rotor vane. The wall of the exhaust channel **530** and the lower flange **610** are clearly seen. The metallic edge **620** is affixed to the leading edge of the lower flange **610**.

A top view of the modified Savonius rotor assembly **400** is shown in **Fig. 9**. From this angle, the 120° shifts in angle are evident between each of the modified Savonius rotors **405, 410, 415**.

Fig. 10 is a view from the concave side of one end of a vane **710** of the modified Savonius rotor **405** in the neighborhood of the axis of rotation. From the angle of **Fig. 10**, the interior of the exhaust channel **530** is clearly seen.

In **Fig. 11**, the direction of view is opposite that of **Fig. 10**. From the angle of **Fig. 11**, the convex side of one end of the vane **710** and the outer wall of the exhaust channel **530** are seen.

A side view of the modified Savonius rotor **405** is shown in **Fig. 12**. On the left, the vane **710** is viewed from its convex side, and the exhaust channel **530** is seen from its outside. On the right, the vane **710** is viewed from its concave side, and the inner surface of the exhaust channel **530** is seen.

Figs. 13 and **14** further detail the exhaust channel **530**. In **Fig. 13**, the view is toward the inside of the exhaust channel **530** whereas **Fig. 14** is a view of the outside of the exhaust channel **530**.

Another view from the open end of the exhaust channel **530** is shown in **Fig. 15**.

Because solar panels are affixed to the outer surfaces of the modified Savonius rotor assembly **400**, the energy produced by the photovoltaic cells must be transferred to the ground for use or storage. Wires **1610** lead from the photovoltaic cells through the hollow shaft **420** towards the ground. Near the power converting device, a slip ring assembly **1710**, shown in **Fig. 17**, is used to transfer the electrical power from the wires **1610** rotating with the shaft **420** to stationary wiring **1720**. The wires **1610** from the photovoltaic cells lead through the hollow shaft **420** to slip rings **1730** that are electrically insulated from each other. Stationary brushes **1740** are forced against the slip rings **1730** and are connected to the wiring **1720** provide the conductive path for the electrical power to take from the rotating slip rings **1730** to the stationary components **1720, 1740**. The stationary wiring **1720** conduct the current to storage, an inverter, or end use.

A second embodiment of the present invention is shown in **Fig. 18** wherein larger support plates **1810** are used in place of the smaller support plates **450** shown in **Figs. 4** and **5** and no photovoltaic cells are utilized. In this preferred embodiment, each support plate **1810** is attached to the top flange **510** and bottom flange **610** by bolts or rivets as shown. Other possibilities for adjoining a support plate **1810** and a vane **710** are by adhesive or combining the top and bottom flanges **510, 610** into one support plate **1810**.

The view shown in **Fig. 19** is similar to that of **Fig. 6** with the addition of the larger

support plate **1810** and the absence of solar collecting material. Again, a metallic edge **1910** is provided on the leading edge of the bottom flange **610**. A detail of a cross section of the vane **710** and metallic edge **1910** is shown in **Fig. 20**. The metallic edge **1910** has a sharpened leading edge to reduce the disturbance to the boundary layer of the flow over the support plate **1910** and bottom flange **610**.

Looking through the top flanges **510** and upper support plate **1810** in **Fig. 21**, the "S" shaped vane **710** of the modified Savonius rotor can be discerned. The exhaust channels **530** are also seen.

Figs. 22 and **23** further detail the exhaust channel **530**. In **Fig. 21**, the view is toward the inside of the exhaust channel **530** whereas **Fig. 22** is a view of the outside of the exhaust channel **530**. The larger support plates **1810** are seen in these views.

A side view of the modified Savonius rotor **405** is shown in **Fig. 24**. On the left, the vane **710** is viewed from its convex side, and the exhaust channel **530** is seen from its outside. On the right, the vane **710** is viewed from its concave side, and the inner surface of the exhaust channel **530** is seen.

Two other views of the exhaust channel **530** for the second embodiment of the invention are shown in **Figs. 25** and **26**. The inside of the exhaust channel **530** is shown in **Fig. 25** whereas the outside of the exhaust channel **530** is shown in **Fig. 26**.

Another view from the open end of the exhaust channel **530** is shown in **Fig. 23**.

A third embodiment of the modified Savonius rotor assembly **400** is shown in **Fig. 28** wherein the assembly shown in **Fig. 18** is outfitted with the addition of a cone-shaped solar collector **2810** at its top. Separate isosceles triangular sections **2820** of photovoltaic solar cells are creased so as to have a ridge running from the top apex to the base. These individual triangular sections **2820** are adjoined to produce the cone shape. As shown, the cone has an included angle of 120°.

The above embodiment is the preferred embodiment, but this invention is not limited thereto. It is, therefore, apparent that many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.